

## Assignment 1

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**1.1** The main idea in systems thinking consist in that we divide whole system by smaller parts and consider how this parts works together over time.

**1.2 P:** the inventory of finished goods has declined steadily;

**H:** problem is occurred because a manufacturing business produce less then they sales. In term of structure (flow and stock) outflow is greater then inflow.

**A:** because if outflow greater then inflow, the amount of finished goods in stock decrease, and if nothing to do, soon it will become empty.

**P:** we need to increase inflow to the level of outflow or greater, in other words we need to increase a production.

**I:** works overtime or find new workforce to increase a production.

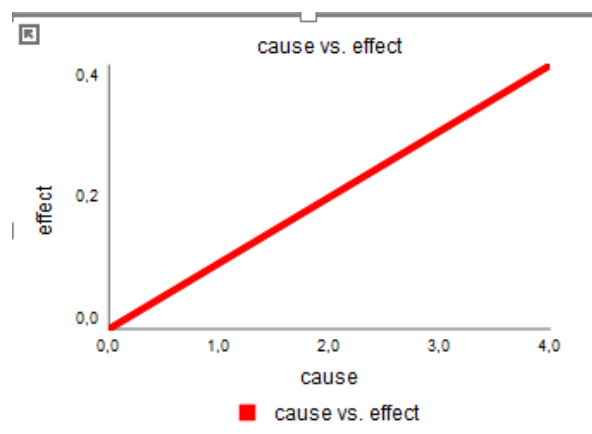
**2.1** Two reasons to identify a reference mode:

1) Define the time horizon on which we will be study the problem;

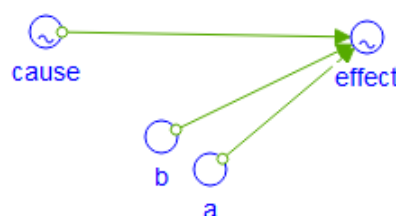
2) Identify boundary for study the problem.

**3.1** The are two types of instantaneous cause and effect relationships:

1) Linear, which can be determined by the following formula:  $\text{Effect} = \text{Cause} * a + b$ , where a, b some constant. In graph below some example.



In image below we can see a Stock and Flow diagram of linear cause and effect relationship.



2) Nonlinear relationship, which can be determined by the following formula:

Effect =  $f(\text{Cause})$ , where  $f$  some function from “Cause”.

### 3.2

- effect of interest rate (%) on interest payments (euros) has instantaneous relationships and graph is linear;
- effect of production cost (euros) on profits (euros) has instantaneous relationships and graph is linear;
- effect of production (items) on size of inventory (items) has instantaneous relationships and graph is linear;
- effect of amount of water in funnel (liters) on the outflow from the funnel (liters) has instantaneous relationships and graph is linear;
- effect of births (persons) on population size (persons) has instantaneous relationships and graph is linear;
- effect of population size (persons) on births (persons) hasn't instantaneous relationship, because to births we need wait in average 9 month;
- effect of hours studied per day on learning per day has instantaneous relationship and graph is nonlinear, it might be a squared root of Cause;
- effect of velocity (meters per second) on distance (meters) travelled has instantaneous relationships and graph is linear;
- effect of force (N) on acceleration (meters per second squared) has instantaneous relationships and graph is linear;
- effect of acceleration (meters per second squared) on velocity (meters per second) has instantaneous relationships and graph is linear;

### 4.1 a)

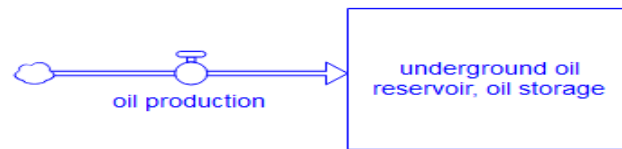


Units for stock: meters<sup>3</sup>;

Units for flow: meters<sup>3</sup>/month;

DT: month.

b)

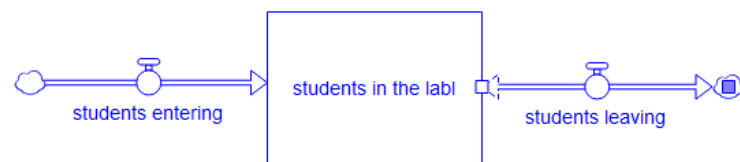


Units for stock: gallons ;

Units for flow: gallons/hour;

DT: hour.

c)

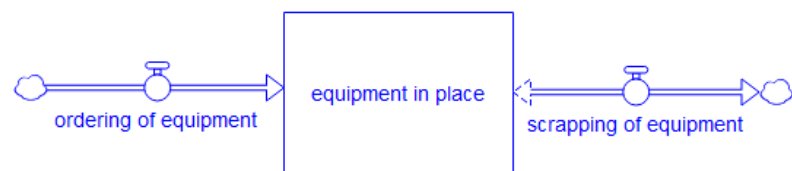


Units for stock: persons;

Units for flow: persons per minute;

DT: minute.

d)

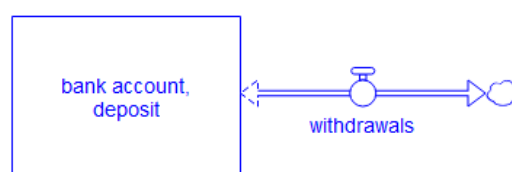


Units for stock: units;

Units for flow: units per day;

DT: day.

e)

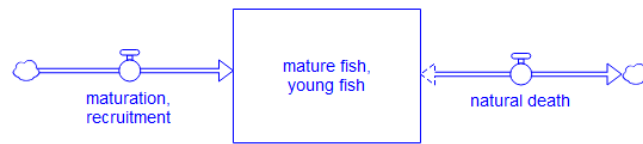


Units for stock: euros;

Units for flow: euros per month;

DT: month.

f)

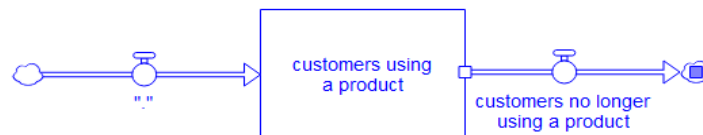


Units for stock: kg;

Units for flow: kg per month;

DT: month.

g)

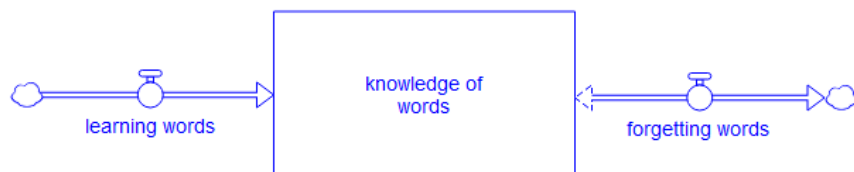


Units for stock: items;

Units for flow: items per month;

DT: month.

h)

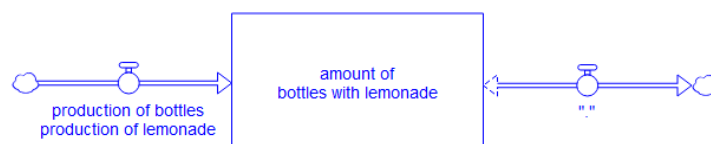


Units for stock: words;

Units for flow: words per hour;

DT: hour.

i)

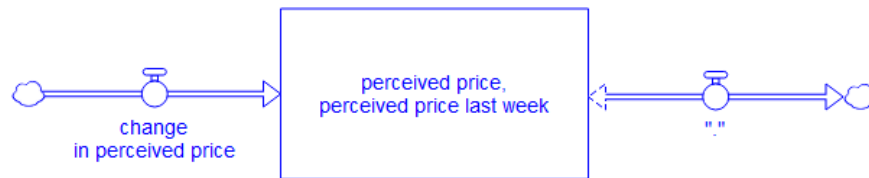


Units for stock: units, liters;

Units for flow: units per hour, liters per hour;

DT: hour.

j)



Units for stock: euros;

Units for flow: euros per hour;

DT: hour

\* "" means that there is no flow at that point.

## 4.2

a) Accuracy determine what time units should use in a model. Because we can use smaller DT, for example "per second", but accuracy of the model can be worse then accuracy with DT "per hour";

b) Because if we consider Euler method for simulation:

$$\text{Stock}(t+1) = \text{Stock}(t) + \text{DT} * \text{Flow}(t),$$

So if we want that the units will be correct, we need to use same time units for DT and Flow. For example, assume that DT measured in day, Stock measured in kg, then it follows that the units for Flow must be a kg per day.

## 4.3.

a) 07.01.2001;

b) 03.01.2001;

c) 13.01.2001;

d) 31.01.2001, 01.01.2001 and 06.01.2001;

e) 08.01.2001;

f) 13.01.2001.